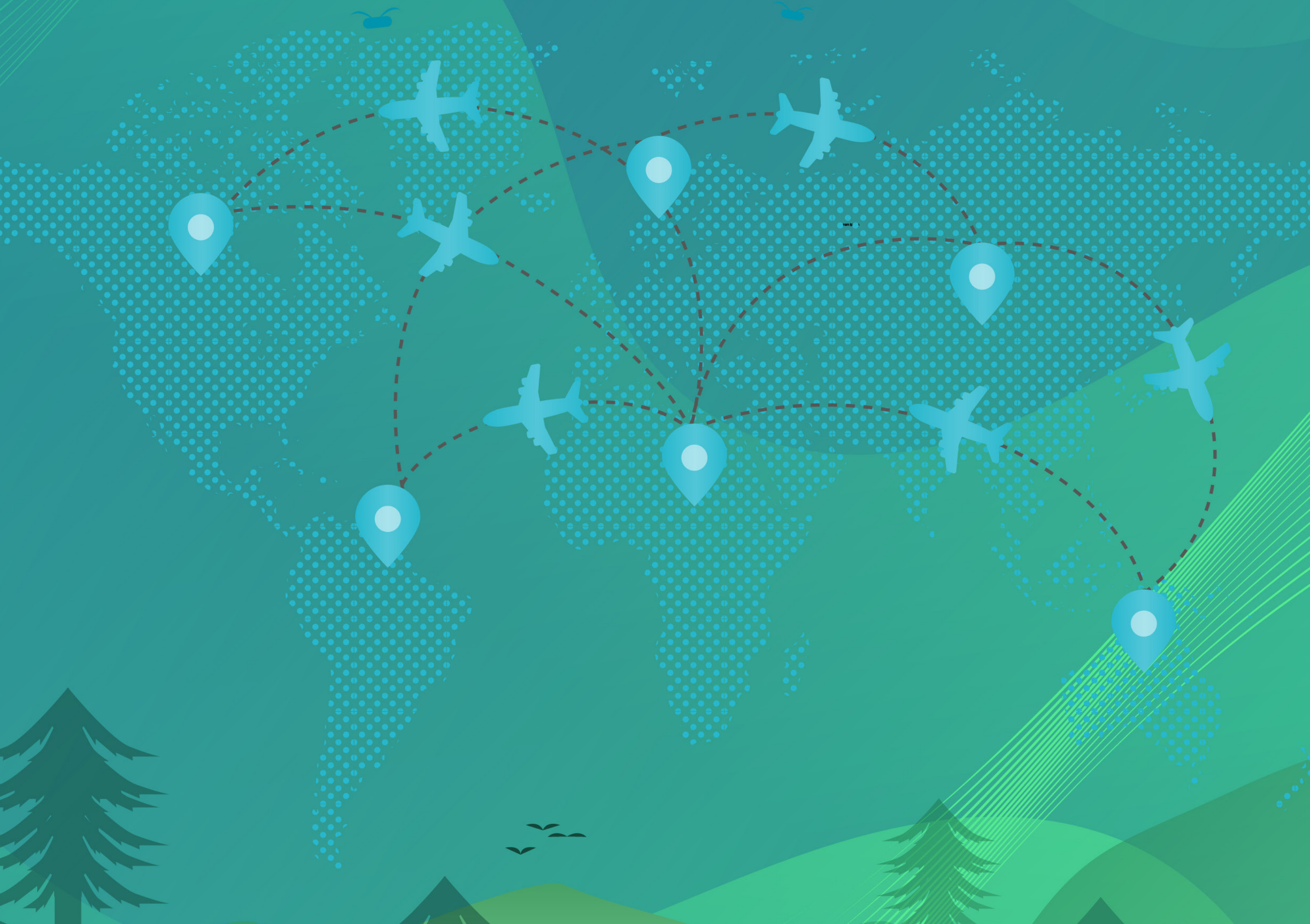
American Journal of Tourism and Hospitality (AJTH)

ISSN: 2993-6519 (ONLINE)

VOLUME 3 ISSUE 1 (2025)



PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Tourism and Hospitality (AJTH)

Volume 3 Issue 1, Year 2025
ISSN: 2993-6519 (Online)
DOI: https://doi.org/10.54536/ajth.v3i1.2829
https://journals.e-palli.com/home/index.php/ajth

Using Fruits and Vegetables to Modify the Formulation of Bread: Effects on Physicochemical Properties and Nutritional Value

Winifred Blankson[1*], Kate Neequaye[1], Frances Betty Fraikue[1], Felix Kudjo Mlagada[1]

Article Information

Received: March 15, 2025
Accepted: April 19, 2025
Published: July 28, 2025

Keywords

Bread, Fruits and Vegetables, Nutritional, Physicochemical Properties, Wheat Bran

ABSTRACT

Bread remained a global dietary staple, yet conventional formulations predominantly relied on refined wheat flour, which lacked essential nutrients. In Ghana, wheat importation has faced increasing challenges due to economic disruptions and global conflicts, necessitating the development of alternative formulations. This study investigated the incorporation of tiger nuts, dates, coconuts, and ginger (TDCG) in bread production, assessing its physicochemical properties and nutritional composition. A cross-sectional survey involving 198 respondents and laboratory analyses evaluated key nutrients, including moisture, ash, protein, fat, fiber, and minerals. The results indicated that TDCG bread exhibited superior fiber, moisture, and mineral content compared to conventional wheat bread, highlighting its potential as a nutritionally enhanced alternative. The findings emphasized the viability of locally sourced ingredients in improving bread quality, reducing dependence on wheat imports, and promoting food security. These insights provided a foundation for sustainable innovations in bakery product development, benefiting consumers, researchers, and industry stakeholders.

INTRODUCTION

Bread is still a staple diet in many countries since it contains a lot of carbohydrates and energy (Goel *et al.*, 2021). But traditional bread recipes mostly use refined wheat flour, which is deficient in vital elements, including vitamins, dietary fiber, and bioactive substances that are needed for good health (Siddiqui *et al.*, 2021). Historically, Ghana has imported wheat to sustain its domestic baking businesses. However, the supply of wheat has become more uncertain and expensive due to recent global disturbances, such as the conflict between Russia and Ukraine and other economic problems (Wineman *et al.*, 2024). Innovative methods of bread formulation that improve nutritional content and lessen dependency on imported wheat are desperately needed to meet this problem (Noort *et al.*, 2022).

One possible technique is the inclusion of locally available fruits and vegetables, which are high in fiber, antioxidants, and critical micronutrients. Although this method has a lot of promise, it also fundamentally alters the bread's physicochemical characteristics, such as its moisture content, water activity, pH, and antioxidant capacity (Fernández-Peláez *et al.*, 2021). Although functional bread formulations are gaining popularity, little is known about how these changes affect the stability, quality, and technological performance of the final product (Taglieri *et al.*, 2021). To create innovative, nutrient-enriched bread formulations that satisfy changing consumer needs and food security issues, this knowledge gap must be filled.

The overall quality, stability, and shelf life of bread are determined by its physicochemical characteristics. While pH and enzymatic interactions impact fermentation and dough rheology, moisture content and water activity impact microbial growth and textural integrity (AL-Ansi *et al.*, 2023). When fruit and vegetable ingredients like dates, coconut, ginger, and tiger nuts are added, bioactive chemicals are introduced that may change the oxidation-reduction balance, impacting the interactions between proteins and starches and changing the structure of the crumb. For example, dietary fiber influences hydration characteristics and starch retrogradation, whereas phenolic chemicals from fruit-based additions can influence the formation of gluten networks.

Additionally, according to Bińkowska *et al.* (2024), the antioxidant properties of several plant-based components can help stabilize lipid oxidation and extend the bread's shelf life. Researchers can find novel ingredient combinations and processing methods that maximize bread's nutritional and physicochemical qualities without sacrificing product integrity by investigating these relationships.

Given the increased focus on sustainable nutrition and food innovation, integrating fruits and vegetables into bread recipes marks a big step toward generating healthier, functionally enhanced bakery goods (Capozzi, 2022). More significantly, using locally accessible plant-based ingredients offers a workable plan to boost food security, lessen supply chain interruptions, and lessen Ghana's dependency on imported wheat (Bour, 2023). However, a methodical assessment of component interactions and processing conditions is necessary to achieve the best possible balance between nutritional enrichment, physicochemical stability, and consumer appeal. This article examines how the addition of fruits and vegetables affects the main physicochemical characteristics of bread, emphasizing new developments, difficulties, and possibilities in product design.

[1] Department of Hospitality Management, Takoradi Technical University, Ghana
[*] Corresponding author's e-mail: winiblankson66@gmail.com

This study offers insights that can help academics, food manufacturers, and policymakers create next-generation, health-conscious bakery goods that satisfy local and international expectations by bridging the gap between food science, technology, and industry applications.

LITERATURE REVIEW

Nutritional Composition of Fruits and Vegetables in Enhancing Dietary Fiber, Vitamins, and Minerals

A healthy diet must include fruits and vegetables because they provide a wide range of bioactive compounds that enhance the overall nutritional quality of the diet (Chaudhari *et al.*, 2024). Because of their high dietary fiber, vitamin, and mineral content, they are essential for maintaining human health and avoiding nutrient deficits. Both soluble and insoluble forms of dietary fiber are essential for preserving gut health, controlling blood sugar, and lowering cholesterol (Giuntini *et al.*, 2022). Fruits that contain soluble fiber, like apples, citrus fruits, and bananas, create a gel-like substance in the digestive tract that slows down digestion and increases feelings of fullness (Hayyat *et al.*, 2024). Conversely, insoluble fiber, which is found in large quantities in plants like spinach, carrots, and lettuce, promotes regular bowel movements and helps avoid constipation.

Fruits and vegetables are a substantial source of vitamins, including fat-soluble and water-soluble varieties (Malik *et al.*, 2023). Collagen production, immunological response, and antioxidant defense all depend on vitamin C, which is mostly present in citrus fruits, kiwis, and strawberries (Sami *et al.*, 2024). Likewise, vitamin A, which is obtained from the carotenoids found in sweet potatoes, carrots, and leafy greens, promotes cell differentiation, immunological response, and eyesight. Furthermore, the B-complex vitamins that are included in green leafy vegetables, avocados, and bananas are essential for brain and energy metabolism. Another important factor in maintaining dietary balance is the mineral content of fruits and vegetables (Vicente, 2022).

Potassium, which is present in oranges, tomatoes, and bananas, is essential for nerve and muscle function as well as fluid homeostasis. Hemoglobin synthesis and blood oxygen transport depend on iron, which is found in spinach and legumes (Imam & Sarkingobir, 2024). In addition to increasing the nutritional density of fruits and vegetables, adding them to a diet also adds phytochemicals that have anti-inflammatory and antioxidant qualities. These bioactive substances lower the risk of chronic illnesses like diabetes, heart disease, and some types of cancer by lowering oxidative stress (Muscolo *et al.*, 2024). Thus, for long-term health and illness prevention, a balanced diet that incorporates a range of fruits and vegetables is essential.

Comparison between Conventional Bread and Enriched Bread

Bread is a staple food around the world; however, its nutritional value can vary significantly depending on how it is made (Aguiar *et al.*, 2023). The processing that traditional bread, which is usually manufactured from refined wheat flour, goes through deprives it of vital elements like vitamins, minerals, and dietary fiber (Iqbal *et al.*, 2022). Because of this, traditional bread typically has a reduced nutritional profile, including mostly carbohydrates and few micronutrients (Mesta-Corral *et al.*, 2024). Nevertheless, extra nutrients are added to enriched bread in order to increase its health advantages.
Whole grains, dietary fiber, protein sources, and micronutrients can all be added to enriched bread to increase its nutritious content. The inclusion of components like bran, seeds, and whole wheat flour increases the amount of fiber, which facilitates digestion and increases feelings of fullness (Guo *et al.*, 2022). Furthermore, vitamins like vitamin C, vitamin A, and folate which support cellular functions and immunological function—are provided by the incorporation of fruits and vegetables in bread compositions. Mineral fortification with iron and calcium supports bone health and oxygen transport while addressing inadequacies (Tiwari *et al.*, 2024). For added health advantages, enriched bread frequently includes functional ingredients including probiotics, omega-3 fatty acids, and plant-based proteins (Wang & Jian, 2022). By adding protein, fiber, and other micronutrients, enhanced bread provides a more balanced nutritional profile than ordinary bread, which is primarily used as an energy source because of its high carbohydrate content. Because enriched bread fills in nutritional gaps, enhances dietary quality, and conforms to contemporary health-conscious consumption patterns, it offers a better option than regular bread.

Effects of Fruits and Vegetables on Macronutrients in Bread: Carbohydrates, Proteins, and Fats

The macronutrient composition of bread is greatly impacted by the addition of fruits and vegetables, which alters the amount of fat, protein, and carbohydrates (Prieto-Vázquez del Mercado, 2022). Bread's main macronutrient is carbohydrates, and adding fruits and vegetables might change how they work and how they are structured. Fruits like bananas, apples, and dates provide natural sugars that can be used as sweeteners, negating the need for additional refined sugars (Milani *et al.*, 2024). Furthermore, the complex carbohydrate proportion is improved by the fiber content of vegetables like spinach and carrots, which lowers the glycemic index and provides a longer-lasting energy release.

Incorporating specific fruits and vegetables into bread recipes also helps proteins. Bread's protein content can be increased by adding legumes, soy, and seeds, which provide vital amino acids required for muscle repair and general bodily functions (King *et al.*, 2024). When mixed with wheat gluten, plant-based proteins help to improve the texture and elasticity of the dough. Moreover, vegetable-based protein isolates can be used to improve the protein content of bread, providing a useful substitute for people on plant-based diets (Quintieri *et al.*, 2023).

The kind and amount of components used in bread composition affect its fat content. Unsaturated fats found in fruits like avocados and coconuts are good for the heart and help control cholesterol (James-Martin, 2022). Nuts and seeds like chia and flaxseeds are added to increase the amount of omega-3 fatty acids, which have anti-inflammatory properties. Fruit and vegetable-enriched bread often has healthier lipid profiles that are in line with dietary guidelines for cardiovascular health, in contrast to traditional bread that could contain saturated fats from butter and refined oils.

In general, adding fruits and vegetables to bread recipes changes the macronutrient composition by adding healthier fats, raising the protein level, and boosting the quality of the carbohydrates (Zarzycki *et al.*, 2024). In line with health-conscious consumption trends and supporting long-term well-being, these nutritional improvements help create a more balanced dietary intake. To further establish enriched bread as a beneficial dietary component, future research should concentrate on refining enrichment techniques to optimize nutrient retention and consumer acceptance.

Physicochemical Properties of Bread

Bread's physicochemical characteristics, which affect its texture, moisture retention, nutritional makeup, and sensory qualities, are essential to its overall quality. These attributes can be broadly divided into bulk and molecular features, which both influence the finished bread's qualities. Molecular characteristics include molecular weight, dipole moment, polarizability, van der Waals volume, and surface area. Bulk characteristics include solubility, octanol/water partition coefficient, and acidity or basicity in solution (Zhang, 2024). Comprehending these elements is essential for refining bread recipes and enhancing product quality. These physicochemical characteristics also interact dynamically, with moisture content and crumb structure playing a particularly important role in determining how consumers view the food and its acceptance as a whole.

One of the most important elements influencing bread quality is its moisture level, which has a direct impact on texture, freshness, and shelf life (Mollakhalili-Meybodi *et al.*, 2024). Too much moisture can cause unwanted sogginess or the growth of mold, while too much dryness makes bread taste stale and unappetizing. According to Zhang *et al.* (2023), achieving the ideal moisture content necessitates careful formulation and regulated baking conditions to balance structural integrity and hydration. The development of the bread's interior structure, also known as the crumb structure, is significantly influenced by moisture (Van Rooyen *et al.*, 2023). Ciabatta bread, which is renowned for its crisp crust and moist, airy crumb, is a prime example of how crucial moisture control is to bread making.

The relationship between moisture and crumb structure emphasizes how important it is to adjust hydration levels precisely in order to maintain a pleasing mouth feel and extended freshness (Mondal *et al.*, 2024).

One of the main factors influencing bread's texture and overall sensory appeal is its crumb structure. Its growth depends on gas retention during fermentation, gluten network synthesis, and yeast activity (Sharanagat *et al.*, 2020). Uniform cell distribution, fine grain, and appropriate flexibility are all characteristics of a well-structured crumb that enhance the eating experience.

According to Clark *et al.* (2024), the production of gluten during the mixing stage aids in gas retention, which is then enlarged by yeast fermentation. The soft, porous texture of fine bread is the result of this expansion. Palatability may suffer from any departure from ideal crumb development, such as an uneven distribution of air cells or inadequate elasticity. The relationship between moisture content and crumb structure highlights how various physicochemical parameters interact to determine bread quality (Khalid *et al.*, 2023).

Another important factor affecting bread quality is its nutritional composition, which establishes both its dietary value and potential health effects (Prieto-Vázquez del Mercado *et al.*, 2022). The final nutritional profile of bread is affected by the type of flour used, the addition of other ingredients, and the processing methods. Compared to refined breads, whole-grain breads are prized for their greater nutritious content, which includes higher levels of dietary fiber, vitamins, and minerals (Kowalski *et al.*, 2022). Bread's nutritional profile is further improved by adding nutrient-dense components like flaxseeds, sunflower seeds, and pumpkin seeds, which supply vital proteins, fatty acids, and minerals. Health-conscious consumers looking for functional foods that support general well-being are catered to by these enriched bread variants.

In close relation to its nutritional qualities, bread's chemical makeup is mostly composed of macronutrients including proteins, lipids, and carbs, as well as fiber and minerals (Kowalski *et al.*, 2022). According to Molakhalili-Meybodi *et al.* (2023), the final composition of bread is greatly influenced by the type of flour used, with differences in the bread's protein and carbohydrate content affecting its texture and nutritional value. Emulsifiers, enzymes, and fortifying agents are examples of additives that can change the chemical structure of bread to improve its nutritional value and sensory appeal. For instance, strengthening gluten with ascorbic acid (vitamin C) increases dough's flexibility and volume expansion while baking. Fortification techniques play a crucial role in treating nutritional deficits while preserving the desired qualities of bread.

Minerals play an important role in bread's nutritional content, texture, colour, and flavour profile (Khalid *et al.*, 2023). Its sensory and functional qualities are influenced by vital minerals like zinc, calcium, magnesium, and iron. Mykolenko *et al.* (2023) state that the type of flour used and any fortification employed during processing have a significant impact on the mineral content of bread. Generally speaking, whole grain flours have more minerals than refined flours, which makes them better options for creating bread. For example, hemoglobin synthesis, which is essential for the human body's oxygen transport, depends on iron. For those at risk of iron deficiency anemia, fortifying bread with iron is very advantageous.

Furthermore, iron affects bread's colour, giving whole wheat and rye bread a slightly darker look that is preferred (Corrado *et al.*, 2023). A workable remedy for iron insufficiency is iron-enriched bread products, especially for people with low dietary iron intake.

Another necessary mineral, calcium supports healthy bones, nerve transmission, and muscular contraction. Additionally, it affects bread's texture and ability to retain moisture, which affects both overall quality and shelf life (Alfaris *et al.*, 2022). Furthermore, calcium promotes the development of gluten, a crucial structural element in bread making that gives the dough its elasticity and strength (Usman *et al.*, 2024). Bread's calcium content can be raised without sacrificing its flavour by using fortification techniques such as the addition of calcium salts or dairy products.

Calcium-enriched bread is especially helpful for groups including children, pregnant women, and elderly persons who need to consume more calcium.

Depending on the substances used in the formulation, vitamins also have a significant impact on the quality of bread. Vitamin E and B-complex vitamins, such as thiamine (B1), riboflavin (B2), and niacin (B3), are frequently found in bread products. These vitamins support energy metabolism and general health (Singh *et al.*, 2023). The nutritional benefits of whole-grain bread are further supported by the fact that whole wheat flour has higher levels of B vitamins than refined white flour.

Processing techniques affect vitamin retention since high temperatures can cause nutritional losses, especially during baking (Bredariol & Vanin, 2022). The significance of component selection and processing methods in maintaining bread's vitamin content is emphasized by Bredariol and Vanin (2022). The nutritional profile of bread products can be improved by manufacturers by adding vitamin-rich components, including almonds, seeds, and fortified flour.

The pH level of bread is another important physicochemical component that affects its quality. The pH of bread dough affects overall stability, crumb structure, and flavour development. To maximize yeast activity and encourage the Maillard reaction, which gives baked bread its desired browning and flavour complexity, a certain pH balance must be maintained (Suchintita Das *et al.*, 2023). Dough elasticity and gas retention are impacted by pH, which influences enzyme stability during fermentation. A somewhat acidic pH environment increases dough handling qualities and strengthens gluten, which helps create a finished product with a good structure. On the other hand, variations in pH can result in unfavourable flavour and texture traits, such as too much sourness or poor crumb formation.

MATERIALS AND METHODS

According to Dampson (2022) and Gupta and Gupta (2022), an experimental research design was an examination in which a controllable factor was given specific treatment. Here, TDCG, a combination of tiger nuts, dates, coconuts, and ginger, is the controlled variable that was maintained throughout the experiment. Because the study was conducted as a cross-sectional survey, the data on X, Y, and Z only captured the state of affairs at one particular moment in time. This research evaluated the composite fiber TDCG utilized in bread manufacture using a cross-sectional survey. Members of the Assemblies of God Central Church, Takoradi in the Western Region, Ghana, were sampled, where 198 respondents were used. The study used a sample size of 208 respondents based on the Cochran sample size formula. The sample size was calculated using a population of 450, a 95% confidence level, and a margin of error proportion p of 0.5.

From the above, the sample size of the study was 208 respondents; however, from the field work, 198 respondents responded to the study. The researcher used a convenience sampling technique to select respondents for the study. Convenience sampling was used because only those who were willing to participate were the respondents for the study. Samples were packaged and sent to the Research Laboratory Department of Laboratory Technology, University of Cape Coast (UCC) for the assessment of the physicochemical properties of the six samples.

Products were developed periodically until a standardized recipe was achieved. In all, unique recipes were developed using Tiger nuts, Dates, Coconuts, and Ginger. Raw materials for the study were purchased from the Takoradi New Market and the Beposo Market. The process of creating bread ratios is figuring out how much flour, water, yeast, fat, and salt to add to get the right texture, flavour, and rise. A standard bread recipe calls for 4 flour and 1 fat (4:1), with minor additions of salt and yeast. Changes in these proportions can produce a variety of breads with changing crumb structure, moisture content, and flavour profiles.

Porcelain crucibles underwent drying, washing, and weighing. Weighing them, 10–12g of the samples were placed into pristine, oven-dried crucibles. To guarantee that the heat was distributed equally throughout the oven, the crucibles holding the sample were placed over the base. After that, they spent 48 hours at 1050c °C in an oven with a thermostat. The samples were taken out after the time, weighed, and allowed to cool in a desiccator. We completed each sample three times.

Sample of Tiger Nuts, Dates, Coconuts, and Ginger (TDCG) Bread

Hard Flour	1500g (3 pounds)
Tiger nuts fibre	250g (1/2 pound)
Dates fibre	250g (1/2 pound)
Coconut fibre	250g (1/2 pound)
Fresh Ginger fibre	250g (1/2 pound)
Margarine	250g (1/2 pound)
Honey	100 millilitres
Yeast	1 teaspoon
Salt	1 teaspoon
Water	450 millilitres

Instructions

1. Combine salt and flour in the large mixing bowl, combine the flour and salt.
2. Add all liquid ingredients (tiger nuts fibre, dates fibre, coconut fibre, and fresh ginger fibre) to the dry mixture and knead until a stiff dough is attained.
3. Knead the dough on a floured surface for about 25-30 minutes until it becomes smooth and elastic. Mould the dough into the desired shapes.
4. Place the shaped loaf into a greased 15x8-inch loaf pan. Cover it and let it prove for about 1 hour and 30 minutes.
5. Preheat your oven to 320°F (150°C). Bake the bread for about 1 hour and 14 minutes or until it is golden brown on top, and it sounds hollow when tapped on the bottom.
6. Remove the bread from the oven and transfer it to a wire rack to cool completely.

RESULTS AND DISCUSSION

In totality, all the samples contained (12) nutrients, of which six (6) were proximate nutrients and six (6) were mineral components. The proximate were moisture, ash, protein, fat, fibre, and carbohydrate. The minerals were phosphorus, potassium, sodium, magnesium, calcium, and iron.

Table 1: Nutritional Composition(Mean ± SD) of Various Bread Samples

	Wheat Bread	Tigernut Bread	Dates Bread	Coconut Bread	Ginger Bread	TDCG Bread	P-value
Moisture (%)	2.16±0.11^{d}	2.25±003^{cd}	2.51±0.14^{b}	2.36±0.09^{bcd}	2.43±0.06^{bc}	2.92±0.04^{a}	0.000
Ash (%)	2.27±0.03^{a}	1.76±0.02^{c}	1.57±0.11^{d}	1.72±0.03^{c}	2.06±0.02^{b}	1.64±0.02^{cd}	0.000
Proteins	12.82±0.15b	13.40±0.13a	11.63±0.11^{c}	11.46±0.11^{cd}	11.65±0.24^{c}	11.200.09^{d}	0.000
Fat (%)	13.33±0.26^{c}	13.87±0.08^{b}	7.91±0.01^{e}	17.34±0.06^{a}	11.01±0.01^{d}	10.89±0.05^{d}	0.000
Fibre (%)	2.68±0.02^{d}	2.71±0.04^{cd}	3.02±0.02^{b}	2.76±0.05^{c}	2.64±0.03^{d}	5.317±0.01^{a}	0.000
Carbohydrates (%)	66.74±0.41^{b}	66.00±0.26^{b}	73.36±0.23^{a}	64.36±0.14^{d}	70.22±0.32^{b}	70.24±0.19^{b}	0.000
Phosphorus (ug/g)	3229.60±37.00a	2328.50±19.40a	2015.16±15.38a	2.30.50±32.70a	6.86x105±1.18x106^{a}	1744.40±45.70a	0.459

Iron (%)	Calcium (%)	Magnesium (%)	Sodium (ug/g)	Potassium (ug/g)
160.00±1.35[d]	1.37±0.00[d]	0.17±0.00[cd]	3264.08±8.97[d]	1792.04±4.93[c]
184.05±0.27[b]	1.27±0.04[e]	0.17±0.00[c]	3488.15±5.17[c]	1867.19±2.76[b]
177.26±2.29[c]	1.39±0.02[d]	0.15±0.00[e]	2931.90±37.90[e]	1810.90±23.40[c]
116.094±1.25[f]	1.58±0.03[c]	0.16±0.00[de]	3754.40±70.70[b]	1648.40±21.70[d]
226.73±2.60[a]	1.86±0.02[a]	0.18±0.00[b]	4051.50±46.50[a]	1819.90±20.90[bc]
132.77±2.64[e]	1.76±0.05[b]	0.19±0.01[a]	3426.70±118.90[cd]	1983.80±23.50[a]
0.000	0.000	0.000	0.000	0.000

This means values with different superscripts across columns are significantly different($p<0.05$)

The TDCG bread (Bread F) moisture, fibre, potassium, and magnesium recorded the highest composition. Gingerbread (Bread E) also revealed that sodium, calcium, and iron were higher than in all other bread samples. Coconut bread (Bread D) contained the greatest fat component, whilst Dates (Bread C) and Tiger nuts (Bread B) also had the most carbohydrates and proteins, respectively. Wheat bran bread (Bread A) had the highest ash and phosphorus nutritional components.

Comparative Analysis between Wheat Bread and TDCG Bread

The wheat bread which were the constant compared to TDCG bread, which was the main focus of the research. General observation of the comparison between wheat bread and TDCG bread revealed that their nutritional component were closely related. In assessing figures 2 and 3, it was observed that wheat bread had more ash, moisture, protein, fibre, and iron content. The TDCG

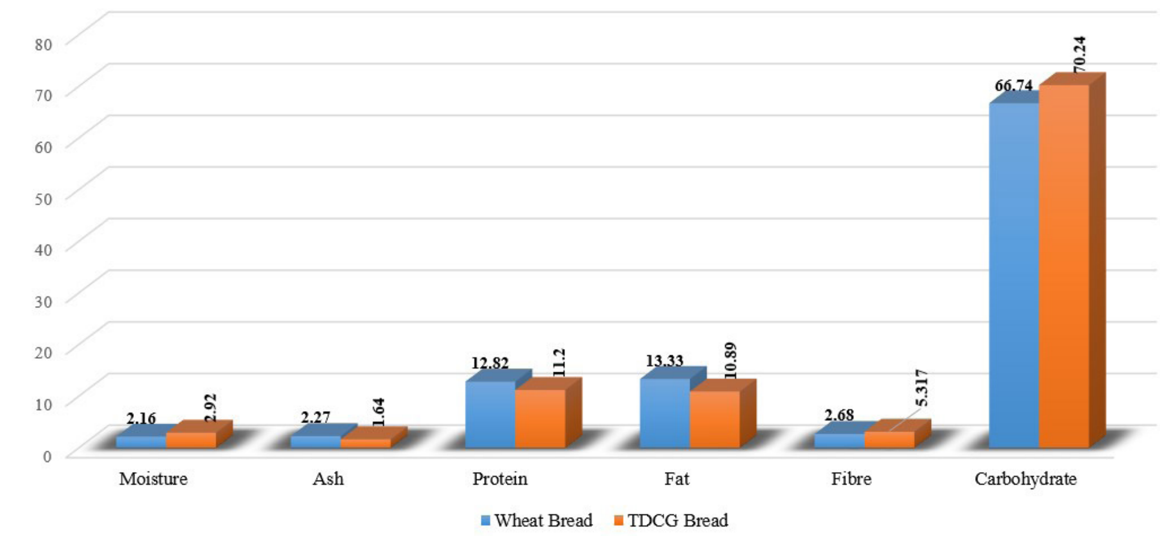


Figure 1: Proximate Composition of Wheat Bran and TDCG Bread
Source: Fieldwork, 2024

bread also had more moisture, carbohydrates, magnesium, and calcium been more than the wheat bread. Still in the comparative study, although there was a gap between wheat bread and TDCG bread, phosphorus was higher in the wheat bread, whilst protein and sodium were higher in the TDCG bread. This comparison also confirms that using our local products for the production of TDCG bread is as nutritious as the imported wheat used for wheat bread.

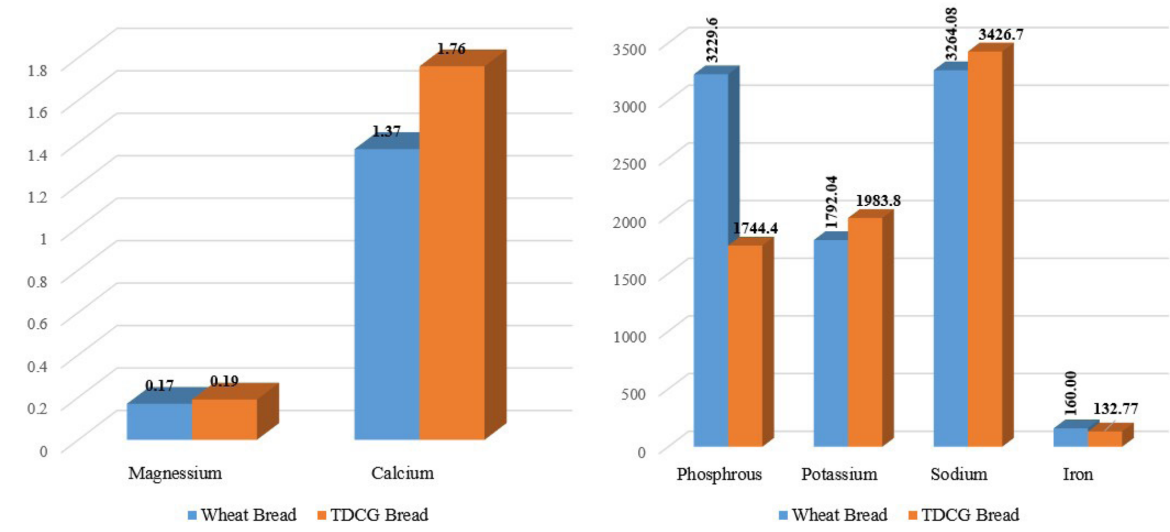


Figure 2: Nutritional Mineral Compositions of Wheat Bran and TDCG Bread
Source: Fieldwork, 2024

The TDCG bread (Bread F) moisture, fibre, potassium, and magnesium recorded the highest composition. Gingerbread (Bread E) also revealed that sodium, calcium, and iron were higher than in all other bread samples. Coconut bread (Bread D) contained the greatest fat component, whilst Dates (Bread C) and Tiger nuts (Bread B) also had the most carbohydrates and proteins, respectively. Wheat bran bread (Bread A) had the highest ash and phosphorus nutritional components.

CONCLUSION

The study found that all bread samples had 12 necessary nutrients, including six minerals (phosphorus, potassium, sodium, magnesium, calcium, and iron) and six proximate nutrients (moisture, ash, protein, fat, fiber, and carbohydrates). While gingerbread had the highest concentrations of sodium, calcium, and iron among the samples, TDCG bread had the highest levels of moisture, fiber, potassium, and magnesium. Tiger nut bread was the most protein-rich, date bread was the most carbohydrate-rich, and coconut bread was the fattiest. Furthermore, wheat bran bread contained the highest quantities of ash and phosphorus. A comparison of TDCG bread and regular wheat bread, which showed comparable nutritional profiles, empirically supported the claim that TDCG bread could be a practical and healthful local substitute for wheat-based choices. The results also showed that the bread samples varied nutritionally, with each kind providing unique health advantages. This difference highlighted the possibility that consumers could choose bread varieties according to their nutritional requirements and tastes. The fact that TDCG bread was confirmed to be nutritionally equivalent to wheat bread further enhanced its marketability as a nutrient-dense, locally sourced substitute. Putting these results into practice could help customers in the baking sector market TDCG bread as a healthier option while promoting a wider use of locally sourced ingredients in bread making. Bread producers were urged to use physicochemical data in their marketing plans to educate consumers about the nutritional benefits of various bread varieties to optimize the advantages of these results. To preserve freshness and increase shelf life, proper storage procedures were also crucial. Refrigeration was advised within 24 hours of baking. To ensure knowledge transfer and skill growth in the industry, specific training sessions should also be planned for people and bakers who are interested in learning how to produce TDCG bread.

REFERENCES

Aguiar, E. V., Santos, F. G., Krupa-Kozak, U., & Capriles, V. D. (2023). Nutritional facts regarding commercially available gluten-free bread worldwide: Recent advances and future challenges. *Critical Reviews in Food Science and Nutrition, 63*(5), 693-705.

AL-Ansi, W., Abdullah, A. B., Alkawry, T. A. A., Fadhl, J. A., Al-Adeeb, A., Mahdi, A. A., ... & Wang, L. (2023). The alterations in the thermomechanical, rheological, and microstructural properties of highland barley dough as affected by fermentation time. *Journal of Food Measurement and Characterization, 17*(6), 6065-6076.

Alfaris, N. A., Gupta, A. K., Khan, D., Khan, M., Wabaidur, S. M., Altamimi, J. Z., ... & Aldayel, T. S. (2022). Impacts of wheat bran on the structure of the gluten network as studied through the production of dough and factors affecting gluten network. *Food Science and Technology, 42,* e37021.

Bińkowska, W., Szpicer, A., Stelmasiak, A., Wojtasik-

Kalinowska, I., & Półtorak, A. (2024). Utilization of Microencapsulated Polyphenols to Enhance the Bioactive Compound Content in Whole Grain Bread: Recipe Optimization. *Applied Sciences, 14*(22), 10156.

Bour, H. (2023). *Food systems mapping: A scoping review of challenges and innovations in Ghana's coastal areas* (Doctoral dissertation, Ensign Global College).

Bredariol, P., & Vanin, F. M. (2022). Bread baking review: Insight into technological aspects to preserve nutrition. *Food Reviews International, 38*(sup1), 651–668.

Capozzi, F. (2022). Food innovation in the frame of circular economy by designing ultra-processed foods optimized for sustainable nutrition. *Frontiers in Nutrition, 9,* 886220.

Chaudhari, V. M., Singh, O. B., Gouthami, N. S., Thakur, N., Singh, R., Singh, S., ... & Nagar, B. L. (2024). Unlocking the nutritional power of vegetables: A guide to vibrant health. *European Journal of Nutrition & Food Safety, 16,* 247–261.

Clark, C. S., Ohstrom, A., Rolon, M. L., Smith, M., Wolfe, B. E., Wee, J., & Van Buiten, C. B. (2024). Sourdough starter culture microbiomes influence physical and chemical properties of wheat bread. *Journal of Food Science, 89*(3), 1414-1427.

Corrado, M., Zafeiriou, P., Ahn-Jarvis, J. H., Savva, G. M., Edwards, C. H., & Hazard, B. A. (2023). Impact of storage on starch digestibility and texture of a high-amylose wheat bread. *Food Hydrocolloids, 135,* 108139.

Dampson, D. G. (2022). Ethical leadership as a predictor of work deviance among public sector workers in administrative offices in the Cape Coast Metropolis, Ghana: a structural equation modelling approach. *Journal of Leadership, Accountability and Ethics, 19*(1), 21-33.

Fernández-Peláez, J., Guerra, P., Gallego, C., & Gomez, M. (2021). Physical properties of flours obtained from wasted bread crusts and crumbs. *Foods, 10*(2), 282.

Giuntini, E. B., Sardá, F. A. H., & de Menezes, E. W. (2022). The effects of soluble dietary fibers on glycemic response: an overview and futures perspectives. *Foods, 11*(23), 3934.

Goel, S., Singh, M., Grewal, S., Razzaq, A., & Wani, S. H. (2021). Wheat proteins: a valuable resources to improve nutritional value of bread. *Frontiers in Sustainable Food Systems, 5,* 769681.

Guo, H., Wu, H., Sajid, A., & Li, Z. (2022). Whole grain cereals: the potential roles of functional components in human health. *Critical Reviews in Food Science and Nutrition, 62*(30), 8388-8402.

Gupta, A., & Gupta, N. (2022). *Research methodology.* SBPD Publications.

Hayyat, F. S., Allayie, S. A., Malik, J. A., & Dar, S. A. (2024). The role of dietary fiber in promoting health: A review of choice and outcomes. In *Food process engineering and technology: Safety, packaging, nanotechnologies and human health* (pp. 493–508).

Imam, A. U., & Sarkingobir, Y. (2024). Significance of dietary iron for human biological system and brain development. *Kaunia: Integration and Interconnection Islam and Science Journal, 20*(1), 1–10.

Iqbal, M. J., Shams, N., & Fatima, K. (2022). Nutritional quality of wheat. In *Wheat—Recent advances.* IntechOpen.

James-Martin, G., Brooker, P., Hendrie, G., & Stonehouse, W. (2022). *A review of the health effects of avocados. Critical Reviews in Food Science and Nutrition.*

Khalid, A., Hameed, A., & Tahir, M. F. (2023). Wheat quality: A review on chemical composition, nutritional attributes, grain anatomy, types, classification, and function of seed storage proteins in bread making quality. *Frontiers in Nutrition, 10,* 1053196.

King, J., Leong, S. Y., Alpos, M., Johnson, C., McLeod, S., Peng, M., ... & Oey, I. (2024). Role of food processing and incorporating legumes in food products to increase protein intake and enhance satiety. *Trends in Food Science & Technology, 144,* 104466.

Kowalski, S., Mikulec, A., Mickowska, B., Skotnicka, M., & Mazurek, A. (2022). Wheat bread supplementation with various edible insect flours: Influence of chemical composition on nutritional and technological aspects. *LWT, 159,* 113220.

Malik, D., Narayanasamy, N., Pratyusha, V. A., Thakur, J., & Sinha, N. (2023). Fat-soluble vitamins. In *Textbook of nutritional biochemistry* (pp. 229–290). Springer Nature Singapore.

Mesta-Corral, M., Gómez-García, R., Balagurusamy, N., Torres-León, C., & Hernández-Almanza, A. Y. (2024). Technological and nutritional aspects of bread production: An overview of current status and future challenges. *Foods, 13*(13), 2062.

Milani, E., Hashemi, N., & Hashemi, M. (2024). Physicochemical properties and flow behaviour of natural sweetener and colorant from foam-mat dried grape powder. *Journal of Food Process Engineering, 47*(2), e14538.

Mollakhalili-Meybodi, N., Sheidaei, Z., Khorshidian, N., Nematollahi, A., & Khanniri, E. (2023). Sensory attributes of wheat bread: A review of influential factors. *Journal of Food Measurement and Characterization, 17*(3), 2172–2185.

Mondal, D., Awana, M., Mandal, S., Pandit, K., Singh, A., Syeunda, C. O., … Krishnan, V. (2024). Functional foods with a tailored glycemic response based on food matrix and its interactions: Can it be a reality? Food Chemistry: X, Article 101358.

Muscolo, A., Mariateresa, O., Giulio, T., & Mariateresa, R. (2024). Oxidative stress: The role of antioxidant phytochemicals in the prevention and treatment of diseases. *International Journal of Molecular Sciences, 25*(6), 3264.

Mykolenko, S., Lebedenko, T., & Ziubrovskyi, A. (2023). Traditional Ukrainian Bread Making. In *Traditional European Breads: An Illustrative Compendium of Ancestral Knowledge and Cultural Heritage* (pp. 389-418). Cham: Springer International Publishing.

Noort, M. W., Renzetti, S., Linderhof, V., du Rand, G. E., Marx-Pienaar, N. J., de Kock, H. L., ... & Taylor, J. R. (2022). Towards sustainable shifts to healthy diets and food security in sub-Saharan Africa with climate-resilient crops in bread-type products: A food system analysis. *Foods, 11*(2), 135.

Prieto-Vázquez del Mercado, P., Mojica, L., & Morales-Hernández, N. (2022). Protein ingredients in bread: Technological, textural and health implications. *Foods, 11*(16), 2399.

Prieto-Vázquez del Mercado, P., Mojica, L., & Morales-Hernández, N. (2022). Protein ingredients in bread: Technological, textural and health implications. *Foods, 11*(16), 2399.

Quintieri, L., Nitride, C., De Angelis, E., Lamonaca, A., Pilolli, R., Russo, F., & Monaci, L. (2023). Alternative protein Sources and novel foods: benefits, food applications and safety issues. *Nutrients, 15*(6), 1509.

Sami, A., Han, S., Haider, M. Z., Khizar, R., Ali, Q., Shafiq, M., ... & Sabir, I. A. (2024). Genetics aspect of vitamin C (ascorbic acid) biosynthesis and signaling pathways in fruits and vegetables crops. *Functional & Integrative Genomics, 24*(2), 73.

Sharanagat, V. S., Singh, L., & Nema, P. K. (2022). Approaches for development of functional and low gluten bread from sorghum: A review. *Journal of Food Processing and Preservation, 46*(11), e17089.

Siddiqui, S. A., Mahmud, M. C., Abdi, G., Wanich, U., Farooqi, M. Q. U., Settapramote, N., ... & Wani, S. A. (2022). New alternatives from sustainable sources to wheat in bakery foods: Science, technology, and challenges. *Journal of Food Biochemistry, 46*(9), e14185.

Singh, B., Pavithran, N., & Rajput, R. (2023). Effects of food processing on nutrients. *Current Journal of Applied Science and Technology, 42*(46), 34-49.

Suchintita Das, R., Tiwari, B. K., & Garcia-Vaquero, M. (2023). The fundamentals of bread making: The science of bread. In *Traditional European breads: An illustrative compendium of ancestral knowledge and cultural heritage* (pp. 1-40). Cham: Springer International Publishing.

Taglieri, I., Macaluso, M., Bianchi, A., Sanmartin, C., Quartacci, M. F., Zinnai, A., & Venturi, F. (2021). Overcoming bread quality decay concerns: Main issues for bread shelf life as a function of biological leavening agents and different extra ingredients used in formulation. A review. *Journal of the Science of Food and Agriculture, 101*(5), 1732-1743.

Tiwari, P., Ramachandran, P., Arshad, N., & Rehman, A. (2024). Fortified beverages. *Just Agric, 4,* 136–146.

Usman, M., Fatima, E., Niaz, A. Q., Sultan, M., Majeed, A., & Mukhtiar, M. (2024). Vitamin B contents in wheat grain. *Scientific Research Timelines Journal, 2*(2), 38–40.

van Rooyen, J., Simsek, S., Oyeyinka, S. A., & Manley, M. (2023). Wheat starch structure–function relationship in breadmaking: A review. *Comprehensive Reviews in Food Science and Food Safety, 22*(3), 2292–2309.

Vicente, A. R., Manganaris, G. A., Darre, M., Ortiz, C. M., Sozzi, G. O., & Crisosto, C. H. (2022). Compositional determinants of fruit and vegetable quality and nutritional value. In *Postharvest handling* (pp. 565–619). Academic Press.

Wang, Y., & Jian, C. (2022). Sustainable plant-based ingredients as wheat flour substitutes in bread making. *npj Science of Food, 6*(1), 49.

Wineman, A., Mwakiwa, E., Agyei-Holmes, A., Fall, M. G., Kirimi, L., Mpenda, Z., … Tschirley, D. (2024). Price shocks and associated policy responses stemming from the Russia-Ukraine war and other global crises: Evidence from Ghana, Kenya, Nigeria, Senegal, Tanzania, and Zimbabwe.

Zarzycki, P., Wirkijowska, A., Teterycz, D., & Łysakowska, P. (2024). Innovations in wheat bread: Using food industry by-products for better quality and nutrition. *Applied Sciences, 14*(10), 3976.

Zhang, S., Chen, Y., McClements, D. J., Hou, T., Geng, F., Chen, P., & Deng, Q. (2023). Composition, processing, and quality control of whole flaxseed products used to fortify foods. *Comprehensive Reviews in Food Science and Food Safety, 22*(1), 587–614.

Zhang, Z. (2024). Advancing chemical hazard and risk assessments: Insights from chemical property prediction and multimedia mass-balance modeling (Doctoral dissertation, University of Nevada, Reno).